Oct. 25, 1955 R. B. TROUSDALE 2,721,938

PULSE GENERATING MEANS

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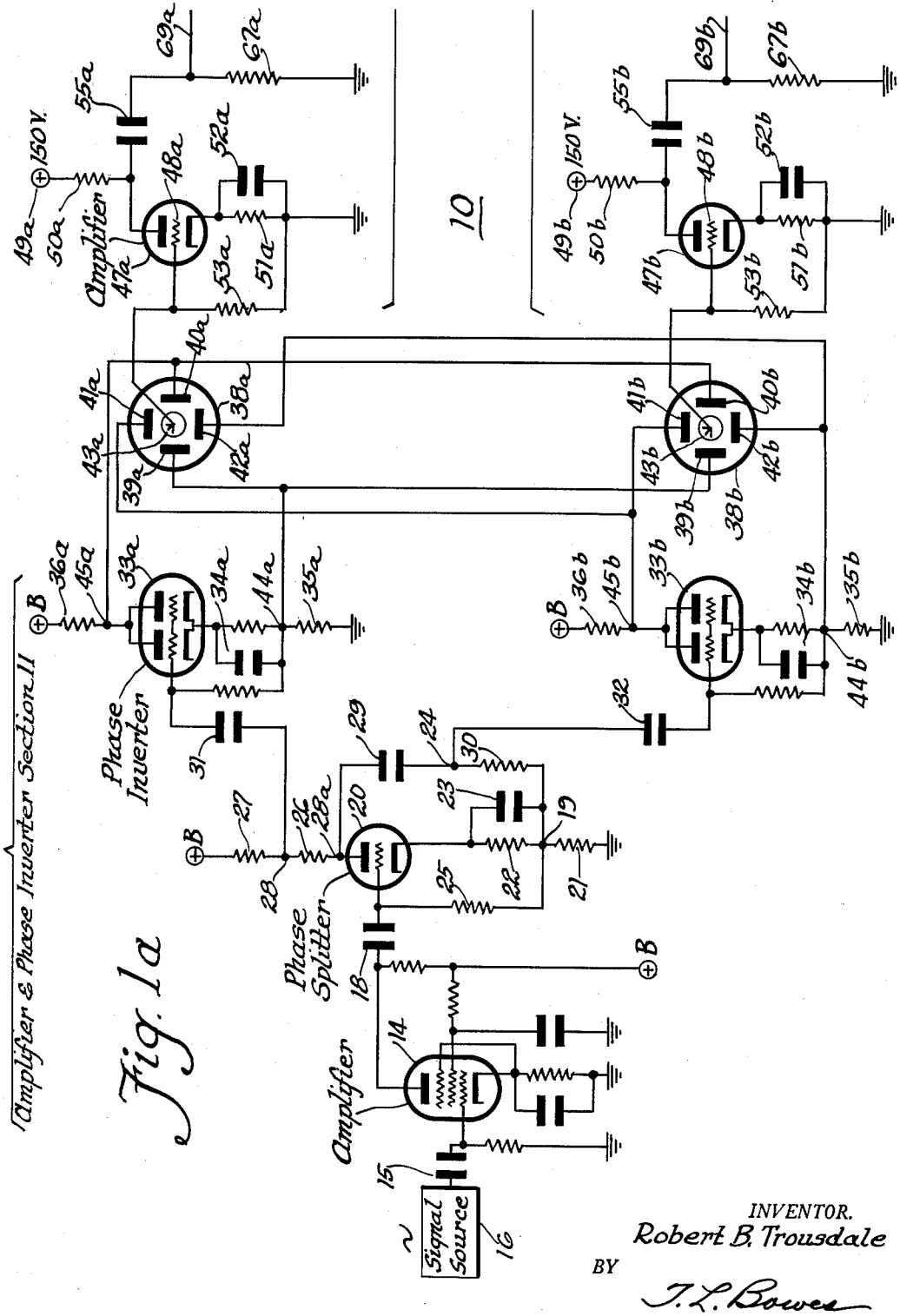


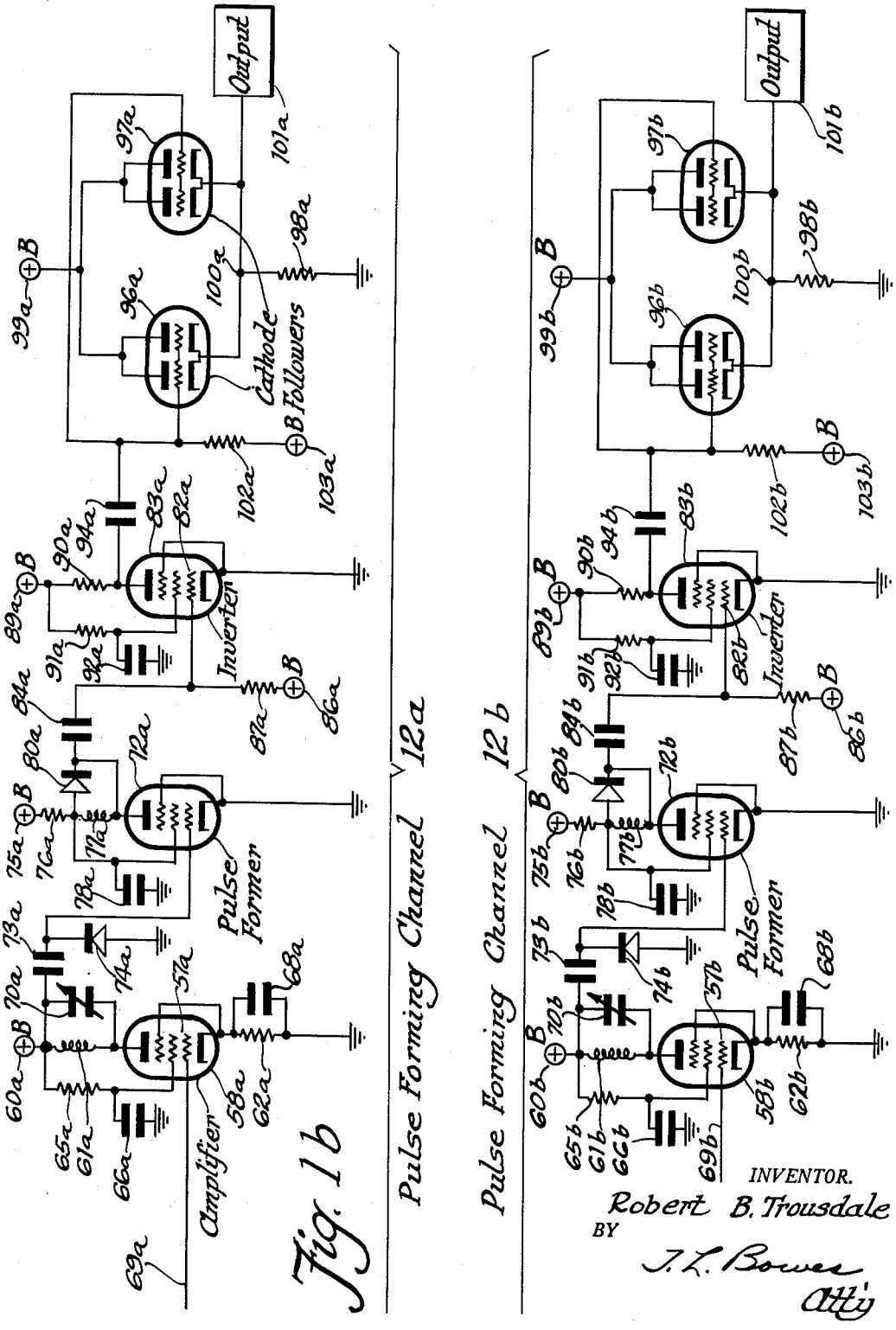
Fig. 1a

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PULSE GENERATING MEANS

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2,721,938

PULSE GENERATING MEANS

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14 Claims. (Cl. 250—27)

The present invention relates to pulse generating means and more particularly a control arrangement for producing from a source of sine wave or other signal a plurality of independent pulse trains including means for adjusting the phase between the pulses of one train relative to the pulses of the other train through a wide angle.

In many electronic control arrangements it is customary to employ pulse signals for initiating control operations and the like. For example, in automatic telephone systems of the type disclosed and claimed in copending Morris and Trousdale application Serial No. 134,974 filed December 24, 1949 and assigned to the same assignee as the present application, pulse signals are extensively employed for circuit gating operations as well as carrying intelligence. In such a system, signal gating pulses are employed and controlled so as to permit intelligence carrying signal pulses to flow at certain times. It will be understood that in a complicated system such signal pulses may suffer small time displacements due to delays in transmission lines and in switching circuits. To accommodate such displacements, gating pulses which open or close gates for intelligence carrying signal pulses, are made essentially square and adjoining one another while the intelligence carrying signal pulses are made as short as is practicable. Under these conditions an intelligence carrying signal pulse might deviate from its normal position to the extent of one-half the width of a gating signal pulse and consequently would not pass through the gate. It would be desirable to provide two trains of signal pulses, the relative phase positions of which could be accurately controlled whereby one train of pulses might be employed as gating signal pulses and the other train of pulses might be employed for carrying intelligence, and wherein it is possible to cause the intelligence carrying signal pulses to occur approximately midway between the gating signal pulses to be sure that the gate is open when the intelligence pulses occur. It is furthermore desirable to be able to move the relative phase positions of the two trains of pulses to accommodate any shift in phase occurring anywhere in the system.

Accordingly, it is an object of the present invention to provide a new and improved arrangement for producing two trains of pulses, the time phase positions of which are accurately controlable relative to each other throughout 360°.

It is another object of the present invention to provide a signal source with means for deriving two trains of pulses adjustable in phase with respect to each other and of the same frequency as the original signal.

Still another object of the present invention is to provide an electronic circuit arrangement capable of producing two independent pulse trains of the same frequency wherein the relative phase positions of the pulses in each train may be accurately controlled.

It is another object of the present invention to provide a pulse producing arrangement wherein pulses of very narrow width and predetermined frequency may be accurately produced and the relative phases thereof controlled.

Further objects and advantages of the present invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the present invention reference may be had to Figs. 1*a* and 1*b* which together represent a schematic circuit diagram illustrating the present invention.

The present invention comprises a circuit arrangement for converting a sine wave from a suitable signal source having a predetermined frequency to two independent pulse trains each having the same frequency as the signal source and each comprising very narrow pulse widths with the phase of the pulses in the respective trains being adjustable relative to each other throughout 360 degrees. The sine wave signal from the suitable source is amplified and split into two components 90° apart by means of a suitable phase splitting device. Furthermore, by means of a phase inverter the two components are divided into four components each displaced in phase by 90° from the preceding one, which four components are supplied to the plates of two suitable four-phase condensers each disposed in a separate channel. By adjusting the four-phase condensers there may be obtained two trains of signals displaced in phase in any desirable manner which are supplied through several amplification stages to pulse forming stages wherein very narrow pulses are produced in each channel. The pulse trains from the two channels are supplied through suitable inverters and cathode follower circuits to output circuits where there appear pulse trains of the same frequency as the frequency of the original signal with the pulses in the two-trains accurately adjustable as far as the relative phase positions are concerned whereby it is possible to cause the pulses in one train to occur in time phase exactly between the pulses in the other train or in some other predetermined arrangement.

Referring now to the drawings there is illustrated an arrangement **10** embodying the present invention which comprises an amplifier and phase inverter section **11** common to two identical pulse forming channels **12***a* and **12***b*. These two pulse forming channels comprise identical circuit components interconnected in the same way. Accordingly, reference numerals, distinguished by the subscripts *a* and *b*, have been employed to identify corresponding components of the two channels. In detail, the amplifier and phase splitting section **11** comprises a high gain pentode amplifier tube **14** which by way of example may be of the 6AK5 type having its input electrodes coupled through a coupling condenser **15** with a source **16** of sine wave potential, which might comprise an oscillator or the like, and its output electrodes coupled through a coupling condenser **18** to the input electrodes of a phase splitting tube **20** which might be of the 6C4 type. The pentode amplifier **14** is connected in a conventional amplifier circuit including conventional circuit elements forming no part of the present invention. One satisfactory circuit is illustrated, but to simplify the description some of the circuit elements are not identified by reference numerals.

To provide the desired phase splitting the tube **20** is provided with a cathode load resistor **21** connected in series with a cathode bias resistor **22** which is shunted by a by-pass condenser **23**. The common terminal between resistors **21** and **22** is designated by the reference numeral **19**. The direct current component of the voltage developed across the resistor **22** is negatively applied

as a bias voltage to the control grid of the tube **20** through a resistor **25**. This phase splitting tube **20** is also provided with an anode load circuit which comprises two series connected resistors **26** and **27** having a combined resistance somewhat higher than the resistance of the cathode load resistor **21**. The terminals of the resistor **26** are specifically designated as **28** and **28***a* respectively. A phase splitting circuit comprising a condenser **29** and resistor **30** connected in series between the anode of the tube **20** and the terminal **19** of the cathode load resistor **21** is provided to perform the phase splitting operation described more fully below. The common terminal of the series resistor **30** and capacitor **29** is designated as **24**.

The phase splitting tube **20** is coupled through coupling condensers **31** and **32**, respectively, to excite the input electrodes of two phase inverter tubes **33***a* and **33***b*. Each of the tubes **33***a* and **33***b* is of the twin triode type, such, for example, as the 6J6, having its anodes, control grids and cathodes connected in parallel. As shown, the tube **33***a* is provided with a self-biasing network **34***a*, a cathode load resistor **35***a* and an anode load resistor **36***a*. Similarly, the phase inverter tube **33***b* is provided with a self-biasing circuit **34***b*, a cathode load resistor **35***b*, and an anode load resistor **36***b*. Each of the two phase inverter tubes delivers two phase displaced input signals to each of the two pulse forming channels **12***a* and **12***b*.

Considering the pulse forming channel **12***a* only, since the channel **12***b* is identical, this channel comprises a four-phase condenser **38***a* having four stator plates **39***a*, **40***a*, **41***a* and **42***a* which are physically displaced by 90 degrees and within which is rotatably mounted a specially shaped rotor **43***a* capable of rotation through an angle of 360 degrees or more. The stator plates **39***a* and **40***a* are respectively connected to the terminal **44***a* of the cathode load resistor **35***a* and the anode terminal **45***a* of the phase inverter tube **33***a*, whereas the two remaining stator plates **41***a* and **42***a* are respectively connected to the anode terminal **45***b* of the phase inverter tube **33***b* and the terminal **44***b* of the cathode load resistor **35***b*.

The signal voltage developed between the rotor **43***a* of the four-phase condenser **38***a* and ground is impressed upon the input electrodes of a triode amplifier tube **47***a* which may be of the well known 6C4 type having its control electrode **48***a* connected to the rotor **43***a*. The plate circuit of the triode amplifier **47***a* is connected to a source of +B potential **49***a* through a current limiting resistor **50***a* and a cathode resistor **51***a*. This latter resistor is paralleled by a by-pass condenser **52***a*. The control electrode **48***a* is connected to ground through a suitable biasing resistor **53***a*. This amplifier tube **47***a* feeds its amplified signal output voltage through a coupling condenser **55***a* to the control electrodes **57***a* of a second high gain pentode amplifier tube **58***a* which may be of the well known 6AK5 type. The pentode **58***a* is connected in the conventional amplifier circuit with the plate circuit connected to a source **60***a* of +B potential through an anode inductance **61***a* and a cathode resistor **62***a*. The screen grid of the tube **58***a* is connected to the +B source **60***a* through a voltage dropping resistor **65***a* and the conventional by-pass condenser **66***a* is also included. The control electrode **51***a* is also connected to ground through a resistor **67***a*, and the cathode resistor **62***a* is shunted by a capacitor **68***a*.

The inductance **61***a* is paralleled by an adjustable capacitance **70***a* to provide in the output circuit of the pentode amplifier tube **58***a* a tuned circuit resonant at a predetermined signal frequency, such, for example, as the frequency of the input **16**. The voltage developed across this resonant circuit is impressed upon the input electrodes of a pulse forming tube **72***a* through a coupling condenser **73***a*. This tube may also be of the commercial 6AK5 and has its input electrodes shunted by a crystal rectifier **74***a*. The plate circuit of the pulse former tube **72***a* is connected to a source of +B potential **75***a* through a current limiting resistor **76***a* and an inductance **77***a*. The suppressor grid of this tube is connected to the grounded cathode thereof while the screen grid is connected to the source **75***a* through the resistor **76***a*. The screen grid by-pass condenser **78***a* completes the circuit of the pulse former tube **72***a*. The inductance element **77***a* effectively is disposed in the output of the pulse forming tube **72***a* and in accordance with the present invention is self-resonant at a frequency substantially higher than the frequency of the input circuit **16**. For example, if the input circuit has a frequency of one megacycle, then the element **76***a* may have a self-resonant frequency in the order of two and one-half megacycles. This self-resonating inductance element is shunted by a crystal rectifier **80***a*. The voltage developed across the shunt connected elements **77***a* and **80***a* is impressed upon the control electrode **82***a* of an inverter tube **83***a* through a coupling condenser **84***a*. This inverter tube is preferably a pentode and may be of the 6AK5 type. As illustrated, the control grid **82***a* of the inverter tube **83***a* has a positive bias potential from the +B source **86***a* applied thereto through a suitable current limiting resistor **87***a*. The plate circuit of the inverter tube **83***a* is connected to the +B source **89***a* through a current limiting resistor **90***a*, and the screen grid thereof is also connected to the source **89***a* through voltage dropping resistor **91***a*. A conventional screen grid by-pass capacitor **92***a* is also included.

The signal voltage developed at the anode of the inverter tube **83***a* is fed through a coupling condenser **94***a* to the control grids of two parallel connected cathode follower tubes **96***a* and **97***a* having a common cathode load resistor **98***a* while their plates are connected directly to the +B potential source **99***a*. These two cathode follower tubes may be of the twin triode 6J6 type having their anodes, control grids and cathodes respectively connected in parallel. The cathode load resistor **98***a* of the two cathode follower tubes **96***a* and **97***a* functions as the output load impedance of the pulse forming channel **12***a* and the cathode terminal **100***a* of this resistor **98***a* is connected to the output or utilization circuit generally designated as **101***a*.

In considering the operation of the phase shift and pulse forming circuit **10**, it will be understood that the input sine wave signal voltage from source **16** is impressed between the cathode and control grid of the amplifier tube **14** through the coupling condenser **15**. This voltage is amplified through the tube **14** and impressed between the control grid and cathode of the phase splitting tube **20** through the coupling condenser **18**. The phase splitting tube **20** is characterized by a low mu factor and performs the function of developing two sine wave voltages at the circuit terminals **24** and **28** which are displaced in phase by 90 degrees. More specifically, the signal voltage developed at the terminal **28***a* of the anode circuit is displaced in phase by one hundred and eighty degrees relative to the signal voltage developed at the cathode load resistor terminal **19**. These two voltages are of substantially equal amplitude and are fed to the phase splitting circuit consisting of the condenser **29** and the resistor **30**. As a result of the phase splitting action of these two series connected circuit elements, a resultant voltage is developed at the terminal **24** and impressed upon the control grids of the phase inverter tube **33***b* through the condenser **32** which is phase displaced by 90 degrees relative to the signal voltage appearing at either of the two anode circuit terminals **28** or **28***a*. The phase inverter tube **33***b* responds to the excitation voltage thus impressed upon its control grid by developing signal voltages of equal amplitude at its anode circuit terminal **45***b* and cathode load resistor terminal **44***b* which are phase displaced by 180 degrees. These voltages are respectfully impressed upon the stator plates **41***a* and **42***a* of the four-phase condenser **38***a*. Similarly, the signal voltages developed at the terminal points **45***b* and **44***b* of the phase inverter stage **33***b* are respectively impressed

upon the stator plates 41*b* and 42*b* of the four-phase condenser 38*b*.

As indicated above, the signal voltage developed at the anode circuit terminal point 28 of the phase splitting stage 20 is phase displaced 90 degrees relative to the signal voltage developed at the circuit terminal 24. The voltage appearing at the terminal point 28 is impressed upon the input electrodes of the second phase inverter tube 33*a* through the coupling condenser 31 to produce signal voltage at the anode terminal point 45*a* and the cathode load resistor terminal 44*a* which are of equal amplitude but are phase displaced by one hundred and eighty degrees. These signal voltages are respectively impressed upon the stator plates 39*a* and 40*a* of the four-phase condenser 38*a* and upon the corresponding stator plates 39*b* and 40*b* of the second four-phase condenser 38*b*.

From the preceding explanation, it will be understood that the three tubes 20, 33*a*, and 33*b* in cooperation with the circuit elements interconected therewith respond to the amplified signal voltage of the frequency of the input circuit 16 delivered to the tube 20 by producing four sine wave signal voltages of the same frequency and equal amplitude which are respectively displaced in phase by 90 degrees and which are respectively impressed upon the four stator plates of each of the four-phase condensers 38*a* and 38*b*. It is of importance to maintain amplitude equality between these signal voltages, and it is to this end that the combined plate or anode load resistance afforded by the resistors 26 and 27 in the anode circuit of the phase splitting tube 20 is made substantially greater than the resistance of the cathode load resistor 21. In this connection, it is noted that since the input electrode biasing resistor 22 of the tube 20 is by-passed at the signal frequency by the condenser 23, it does not substantially affect the cathode load resistance of the tube 20 at this frequency. The necessity for making the anode load resistance of the tube 20 appreciably higher than the cathode load resistance of the tube is dictated by the fact that the cathode impedance of the tube is very low and is virtually unaffected by stray capacitance, whereas the plate impedance of the tube is relatively high and hence the magnitude of the signal voltages appearing at the circuit terminals 28*a* and 28 is very substantially affected by the shunting effect of stray capacitance. However, by employing a load resistance for the tube 20 having a value appreciably higher than the resistance value of the cathode load resistor 21, this effect is overcome with the result that the voltages produced at the circuit terminals 28*a* and 19 are equalized. It has been found that entirely satisfactory results may be obtained by employing resistors 26 and 27 having resistance values of 2700 and 2400 ohms, respectively, and using a cathode load resistor 21 having a resistance value of 3900 ohms. Resistance values higher than those just given cannot be employed satisfactorily since the use of higher value resistors has the effect of altering to an appreciable extent the desired one hundred and eighty degree phase relationship between the signal voltages developed at the circuit terminals 28*a* and 19.

Further to the end of obtaining amplitude equality between the signal voltages supplied to the four stator plates of each of the condensers 38*a* and 38*b*, the anode and cathode load resistors 36*a* and 35*a* of the tube 33*a* are selected to have relatively low and unequal resistance values, such that the voltages appearing at the circuit terminals 45*a* and 44*a* are of equal amplitude. Similarly, the anode and cathode load resistors 36*b* and 35*b* of the inverter tube 33*b* are selected to have unequal resistance values which insure amplitude equality of the signal voltages developed at the circuit terminals 45*b* and 44*b*. Specifically, the desired signal voltage equality at the output terminals of the two phase inverter tubes 33*a* and 33*b* may be obtained by using anode load resistors 36*a* and 36*b* each having a resistance value of 560 ohms and by using cathode load resistor 35*a* and 35*b* each having a resistance value of 470 ohms.

As indicated above, by virtue of the 90 degree phase relationship between the signal voltages delivered to the control grids of the two phase inverter tubes 33*a* and 33*b* and because of the one hundred and eighty degree phase relationship obtained between the two signal output voltages of each of these inverter tubes, the four stator plates of each of the four-phase condensers 38*a* and 38*b* are excited by signal voltages of equal amplitude which are displaced in phase by 90 degrees and which have a frequency equal to that of the input circuit 16.

From this point on only the operations which occur in the pulse forming channel 12*a* will be described, since those occurring in the second pulse forming channel 12*b* are identical. The rotor element 43*a* of the four-phase condenser 38*a* is so shaped and positioned relative to the four stator plates as to have a signal voltage developed thereon which varies in phase relative to the condenser stator voltages as a function of the vector sum of the electrostatic fields embraced thereby. Hence by rotating this element to a particular position relative to the four stator plates, a signal voltage is developed on this element having the desired phase relationship relative to the signal voltage developed on the rotor 43*b* of the condenser 38*b*. In other words, through rotation of the rotor elements 43*a* and 43*b* signal voltages are developed on these elements which may be varied in phase relative to each other through any desired phase angle up to and including 360 electrical degrees. Moreover, this adjustment of the phase relationship between the signal voltages produced on the rotor elements 43*a* and 43*b* of the two condensers is obtained without varying the amplitude of the voltage on either rotor element.

The voltage developed between the rotor element 43*a* and ground is impressed between the cathode and control grid of the amplifier tube 47*a* in an obvious manner and after amplification through this tube is impressed upon the input electrodes of the second amplifier tube 58*a* through the coupling condenser 55*a*. As a result of the signal amplification produced by the two tubes 47*a* and 58*a* and the additive action of the tuned circuit comprising inductance 61*a* and capacitance 70*a* which increases the amplitude of the signal voltage, this voltage as impressed between the cathode and control grid of the pulse former tube 72*a* through the condenser 73*a* is of sufficient amplitude completely to overload the pulse former tube 72*a*. More specifically, during each positive half cycle of the signal voltage appearing across the tuned circuit comprising inductance 61*a* and capacitor 70*a*, the control grid of the pulse former tube 72*a* in conjunction with the crystal rectifier 74*a* conduct, thus charging the coupling condenser 73*a* to a value equal to the amplitude of the signal voltage. During each negative half cycle of the signal voltage, the control grid potential of the pulse former tube 72*a* is driven well beyond cutoff. In this manner, the signal voltage is clamped to the cathode potential of the tube 72*a*, resulting in an intermittent flow of plate current through the tube 72*a* similar to that which occurs in a class C amplifier.

During each positive half cycle of the signal voltage applied to the control grid of the pulse former tube 72*a*, a sharp increase is produced in the current flow through the self-resonant inductance element 77*a*. As a result, this element is shock excited to develop a transient wave train which oscillates at the natural resonant frequency of the element 77*a*, i. e., at a frequency which is substantially higher than the frequency of the input circuit 16. The character of this wave train is such that during the first half cycle thereof the plate terminal of the element 77*a* is negative relative to the other terminal of the element. Moreover, the shunting crystal rectifier 80*a* is so poled as to be non-conductive during the first half

cycle of the oscillatory transient developed across the element 77*a*. However, when the polarity of the voltage across the element 77*a* reverses during the second half cycle of the oscillatory wave train, the crystal rectifier 80*a* becomes conductive to absorb all of the transient energy stored in the element 77*a*. Thus, only the first half cycle of the oscillatory transient as it appears at the plate terminal of the element 77*a* is permitted to endure. This voltage half cycle or pulse is of negative polarity. Since the element 77*a* is self-resonant at a frequency substantially higher than the frequency of the input circuit 16, it will be understood that the first negative half cycle of each transient wave train produced across this element persists for an extremely short interval. For example, if the resonant frequency of the element 77*a* is 2½ megacycles, the first negative half cycle of each transient wave train produced across this element persists for only one fifth of a microsecond. Thus, as the signal voltage is continuously impressed upon the control grid of the tube 72*a*, pulses of negative polarity are developed across the output circuit of this tube which have a repetition rate which is equal to the frequency of the input circuit 16, i. e. a repetition rate of one megacycle, but in which the pulse persistence interval is limited to one fifth of a microsecond. These successive pulses are obviously spaced by an interval of ⅘ of a microsecond.

The narrow negative pulses thus produced across the output circuit of the tube 72*a* are impressed upon the control grid of the inverter tube 83*a* through the coupling condenser 84*a*. This tube functions to amplify the pulses and invert the same so that they appear as positive pulses at the anode of this tube. In this regard, it is noted that the control grid 82*a* of the inverter tube 83*a* is normally positively biased from the +B source 86*a* through the resistor 87*a* to a value such that plate current flow through the inverter tube 83*a* is at the saturation value. By thus normally biasing the tube 83*a* to the plate current saturation point, the reference potential relative to which the pulses are repeated by the tube 83*a* is positively clamped at a potential slightly above the cathode potential of the tube 83*a*, thereby placing the input wave on that portion of the characteristic of the tube 83*a* whereat the gretaest gain through the tube 83*a* is realized.

The pulses of positive polarity developed at the output side of the inverter tube 83*a* are repeated to the control grids of the cathode follower tube 96*a* and 97*a* in parallel. At this stage, the input pulses are clamped positively by virtue of grid conduction of the two tubes. In order to provide a tighter clamp with larger plate currents and output pulses as a result, the control grids are returned through the resistor 102*a* to the +B source 103*a*. The pulses applied to the control grids of the two cathode follower tubes 96*a* and 97*a* are obviously repeated across the cathode load resistor 98*a* common to these two tubes. This resistor functions as the output load impedance of the pulse forming channel 12*a*. More particularly, the output circuit 101*a* is connected to the cathode terminal of the resistor 98*a* such that the narrow pulses formed in the channel 12*a* are repeated positively at the input terminal of the output circuit 101*a*.

The second pulse forming channel 12*b* operates in exactly the same manner as the pulse forming channel 12*a* to produce positive pulses each having a pulse persistence interval of one fifth microsecond and having a repetition rate of one megacycle for the condition assumed above. As will be evident from the above explanation, however, the phase relationship between the pulses respectively developed at the outputs 101*a* and 101*b* may be varied as desired by suitable adjustment of one or both of the four-phase condensers 38*a* and 38*b*. In actual practice, it is preferred to so phase the pulses produced at these outputs that each pulse developed at the output 101*a* is disposed approximately midway between two successive pulses produced at the output 101*b*.

In view of the detailed description included above, it will be apparent that there has been provided an arrangement whereby a sine wave signal may be converted to two separate signals or pulse trains, the relative phase positions of which may be controlled through a wide angle. It will furthermore be apparent that one train of pulses may be employed as intelligence carrying pulses while the other train of pulses may be used as gating pulses. By proper adjustment of the four-phase condensers 38*a* and 38*b* the desired phase relationship between the two trains of pulses is obtainable to the end that the signal carrying pulses may be positioned accurately between the gating pulses if desired or any other phase relationship may be obtained.

While there has been described and illustrated a particular embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention in its broader aspects and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A signal generating system for deriving from a periodic input signal a plurality of phase displaced signals comprising a phase splitter including a first electron discharge valve having anode, cathode and control electrodes and having input and output circuits, means for applying said periodic input signal to said input circuit, a phase splitting impedance circuit effectively connected to the anode and cathode electrodes of said first valve, circuit connections for deriving a first signal of one phase position from the output circuit of said first valve and a second signal of different phase position from said phase-splitting circuit, a second and third electron discharge valve each having anode, cathode and control electrodes and input and output circuits, means for applying said first signal to the input circuit of said second valve, means for applying said second signal to the input circuit of said third valve, each of the output circuits of said second and third discharge valves including separate anode and cathode load impedances of like type for developing output signals of opposite polarity whereby four phase displaced signals are obtained from the output circuits of said second and third valves, a first and second phase controlling means each including an adjustable element, and means for supplying said four phase displaced signals to each of said first and second phase displacing means in a predetermined manner.

2. A signal generating system for deriving from a periodic input signal a plurality of phase displaced signals comprising a phase splitter including a first electron discharge valve having anode, cathode and control electrodes and having input and output circuits, means for applying said periodic input signal to said input circuit, a phase splitting impedance circuit effectively connected to the anode and cathode electrodes of said first valve, circuit connections for deriving a first signal of one phase position from the output circuit of said first valve and a second signal from said phase splitting circuit having a phase position displaced by 90° from said one phase position, a second and third electron discharge valve each having anode, cathode and control electrodes and input and output circuits, means for applying said first signal to the input circuit of said second valve, means for applying said second signal to the input circuit of said third valve, each of the output circuits of said second and third discharge valves including separate anode and cathode load impedances of like type for developing output signals of opposite polarity whereby four signals successively displaced in phase by 90° are obtained, a first and second phase controlling means each including an adjustable element.

and means for supplying said four phase displaced signals to each of said first and second phase displacing means in a predetermined manner.

3. A pulse generating system for deriving from a periodic input signal a plurality of phase displaced signals comprising a phase splitter including a first electron discharge valve having anode, cathode and control electrodes and having input and output circuits, means for applying said periodic input signal to said input circuit, a phase splitting impedance circuit effectively connected to the anode and cathode electrodes of said first valve, circuit connections for deriving a first signal of one phase position from the output circuit of said first valve and a second signal of different phase position from said phase-splitting circuit, a second and third electron discharge valve each having anode, cathode and control electrodes and input and output circuits, means for applying said first signal to the input circuit of said second valve, means for applying said second signal to the input circuit of said third valve, each of the output circuits of said second and third discharge valves including separate anode and cathode load impedances of like type for developing output signals of opposite polarity whereby four phase displaced signals are obtained from the output circuits of said second and third valves, a first and second phase controlling means each including an adjustable element, means for supplying said four phase displaced signals to each of said first and second phase displacing means in a predetermined manner, and a pair of pulse forming means connected to one each of said phase displacing means.

4. In a signal generating system for deriving from a sine wave input signal a plurality of phase displaced signals, the combination of a phase splitter including a first electron discharge valve having anode, cathode and control electrodes and having input and output circuits, means for applying said sine wave signal to said input circuit, a phase splitting impedance circuit effectively connected to the anode and cathode electrodes of said first valve, circuit connections for deriving a first signal of one phase position from the output circuit of said first valve and a second signal of different phase position from said phase splitting circuit, a second and third electron discharge valve each having anode, cathode and control electrodes and input and output circuits, means for applying said first signal to the input circuit of said second discharge valve, means for applying said second signal to the input circuit of said third discharge valve, each of the output circuits of said second and third discharge valves including separate anode and cathode load impedances of like type for developing output signals of opposite polarity whereby four phase displaced signals are obtained, a first and second four phase condenser each including a movable element, means for supplying said four phase displaced signals to each of said first and second condensers in a predetermined manner, and pulse forming means connected to each of said condensers for producing two independent trains of pulses useable as intelligence carrying and gating pulses respectively, said movable elements of said condensers permitting adjustment of the relative phase positions of said pulses whereby said intelligence carrying pulses may be made to bear a predetermined phase relationship relative to said gating pulses.

5. A pulse generating system for deriving from a sine wave input signal a plurality of phase displaced signals comprising means including a first electron discharge valve having anode, cathode and control electrodes and having input and output circuits, means for applying said sine wave input signal to said input circuit, a phase splitting impedance circuit effectively connected to the anode and cathode electrodes of said first valve, circuit connections for deriving a first signal of one phase position from the output circuit of said first valve and a second signal from said phase splitting circuit having a phase position displaced by 90° from said one phase position, second and third electron discharge valves each having anode, cathode and control electrodes and input and output circuits, means for applying said first signal to the input circuit of said second valve, means for applying said second signal to the input circuit of said third valve, each of the output circuits of said second and third discharge valves including separate anode and cathode load impedances of like type for developing output signals of opposite polarity whereby four signals displaced by equal phase increments are obtained, a first and second phase controlling means each including an adjustable element, means for supplying said four phase displaced signals to each of said first and second phase displacing means in a predetermined manner, and a pair of pulse forming channels one connected to each of said phase controlling means for converting the outputs from said phase controlling means to two pulse trains relatively adjustable in phase with respect to the phase of said input signal.

6. In a pulse generating system for deriving from a sine input signal a plurality of phase displaced signals, the combination of a phase splitter including a first electron discharge valve having anode, cathode and control electrodes and having input and output circuits, means for applying said sine wave input signal to said input circuit, a phase splitting impedance circuit effectively connected to the anode and cathode electrodes of said first valve, circuit connections for deriving a first sine wave signal of one phase position from the output circuit of said first valve and a second sine wave signal of different phase position from said phase-splitting circuit, a second and third electron discharge valve each having anode, cathode and control electrodes and input and output circuits, means for applying said first signal to the input circuit of said second valve, means for applying said second signal to the input circuit of said third valve, each of the output circuits of said second and third discharge valves including separate anode and cathode load resistors for developing output signals of opposite polarity whereby four sine wave phase displaced signals are obtained from the output circuits of said second and third valves, a first and second phase controlling means each including an adjustable element, means for supplying said four phase displaced signals to each of said first and second phase displacing means in a predetermined manner, a pair of pulse forming means connected to one each of said phase displacing means for converting said sine wave signals to pulse signals of the same frequency as said sine wave signals.

7. A pulse generating system for deriving from a periodic input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, comprising, a phase splitter and a pair of phase inverters for converting said input signal to four separate signals displaced in phase by four equal phase increments, means for supplying said four phase displaced signals to each of two signal controlling means each including an adjustable member, a pair of pulse forming channels one connected to each of said signal controlling means, and means in each of said pulse forming channels for converting the signals supplied from the associated signal controlling means to pulse signals of narrow pulse widths.

8. A pulse generating system for deriving from a periodic input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, comprising, a phase splitter and a pair of phase inverters for converting said input signal to four signals of the same periodicity as said input signals but displaced in phase by four equal phase increments, means for supplying said four phase displaced signals to each of two

four phase condensers each including a rotor, a pair of pulse forming channels one connected to one each of said condensers, and means in each of said pulse forming channels comprising a shock excited electron discharge valve for producing pulses having a repetition rate equal to the frequency of said input circuit but having a pulse persistence period of only a small fraction of a half cycle of the periodic input signal.

9. In a pulse generating system for deriving from a periodic input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, the combination of means for converting said input signal to two periodic signals each of the same frequency as said input signal including means for varying the relative phase position of said two signals through an angle of substantially 360°, a pair of pulse forming channels, means for supplying one of said two signals to one of said pulse forming channels, means for supplying the other of said two signals to the other of said pulse forming channels, each of said pulse forming channels comprising an amplifier, a pulse former discharge valve and an inverter, a self-resonant inductance in the plate circuit of said pulse former discharge valve self-resonant at a frequency several times greater than the frequency of said input signal, and means including said self-resonant inductance for shock exciting said pulse former discharge valve.

10. In a pulse generating system for deriving from a periodic input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, the combination of means for converting said input signal into two periodic signals each of the same frequency as said input signal including means for varying the relative phase position of said two signals through an angle of substantially 360°, a pair of pulse forming channels, means for supplying one of said two signals to one of said pulse forming channels, means for supplying the other of said two signals to the other of said pulse forming channels, each of said pulse forming channels comprising an amplifier, a pulse former and an inverter, said pulse former comprising an electron discharge valve, a self-resonant inductance in the plate circuit of said electron discharge valve self-resonant at a frequency several times greater than the frequency of said input signal, means including said self-resonant inductance for shock exciting said pulse former discharge valve to produce a pulse signal output having a pulse persistence interval no greater than a half cycle of the frequency at which said inductance is self-resonant.

11. In a pulse generating system for deriving from a periodic input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, the combination of means for converting said input signal into two periodic signals each of the same frequency as said input signal including means for varying the relative phase position of said two signals through an angle of substantially 360°, a pair of pulse forming channels, means for supplying one of said two signals to one of said pulse forming channels, means for supplying the other of said two signals to the other of said pulse forming channels, and means in each of said pulse forming channels comprising a shock excited electron discharge valve for producing pulses having a repetition rate equal to the frequency of said input circuit but having a pulse persistence period of only a small fraction of a half cycle of the periodic input signal.

12. In a pulse generating system for deriving from a sine wave input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and a persistence interval of only a fraction of a half cycle of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, the combination of means for converting said input signal into two sine wave signals each of the same frequency as said input signal including means for varying the relative phase position of said two signals through an angle of substantially 360°, a pair of pulse forming channels, means for supplying one of said two signals to one of said pulse forming channels, and means for supplying the other of said two signals to the other of said pulse forming channels, each of said pulse forming channels comprising a self-resonant inductance having a self-resonant frequency several times greater than the frequency of said input signal, means controlled by one of said sine wave signals for shock exciting said inductance into oscillation at the resonant frequency thereof, and means for suppressing all but the first half cycle of said shock excited oscillations, thereby to produce pulses having a repetition rate equal to the frequency of said input signal but having a pulse persistence period of only a small fraction of one-half cycle of said input signal.

13. In a pulse generating system for deriving from a sine wave input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and a persistence interval of only a fraction of a half cycle of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, the combination of means for converting said input signal into two sine wave signals each of the same frequency as said input signal including means for varying the relative phase position of said two signals through an angle of substantially 360°, a pair of pulse forming channels, means for supplying one of said two signals to one of said pulse forming channels, and means for supplying the other of said two signals to the other of said pulse forming channels, each of said pulse forming channels comprising a self-resonant inductance having a self-resonant frequency several times greater than the frequency of said input signal, means controlled by one of said sine wave signals for shock exciting said inductance into oscillation at the resonant frequency thereof, and means including a rectifier connected across said inductance for suppressing all but the first half cycle of said shock excited oscillations thereby to produce pulses having a repetition rate equal to the frequency of said input signal but having a pulse persistence period of only a small fraction of one-half cycle of said input signal.

14. In a pulse generating system for deriving from a sine wave input signal a pair of separate pulse trains each having a pulse repetition rate equal to the frequency of said input signal and a persistence interval of only a fraction of a half cycle of said input signal and wherein the relative phase positions of the pulses in each train are adjustable through a wide angle, the combination of means for converting said input signal into two sine wave signals each of the same frequency as said input signal including means for varying the relative phase position of said two signals through an angle of substantially 360°, a pair of pulse forming channels, means for supplying one of said two signals to one of said pulse forming channels, and means for supplying the other of said two signals to the other of said pulse forming channels, each of said pulse forming channels comprising a pulse former discharge valve, a self-resonant inductance in the plate circuit of said discharge valve self-resonant at a frequency several times greater than the frequency of said input signal, means for applying one of said sine wave signals to the input circuit of said valve thereby to shock excite said inductance into oscillation at the self-resonant frequency thereof, a rectifier connected across said inductance for suppressing all but the first half cycle of said shock excited oscillations, thereby to produce pulses in said plate

circuit having a repetition rate equal to the frequency of said input signal and having a pulse persistence period no greater than one-half cycle of the self-resonant frequency of said inductance.

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